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THE LARGE SCALE WIND DRIVEN ELECTRICAL GENERATING STATION

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Electrical power generation with wind power is one of the oldest forms of energy production. However, the individual performance of wind wheels is not great enough to play a role in the economics of electrical power generation, even though the wind energy reserves within the atmosphere are similar in magnitude to those of other energy sources. This is connected with the low energy concentration or the low energy flux density of the wind. Also this source of energy is not very continuous [2]. Only over the last few years have projects been suggested which use wind energy on a large scale in large installations. These installations were always heavily used in emergencies. Therefore it is not surprising that wind energy today is looked upon as something which could save us from the present emergency. All serious investigations of this source have led to rejections, or at least to a skeptical evaluation by the scientists and engineers [1].

The author is a heat specialist and would like to state his opinion, because he believes that this problem has not yet been discussed enough from this point of view [3].

In 1943, about 80% of the electrical energy in Germany was produced by steam generating plants, 16% by water generating plants and 4% was produced in generating plants with combustion

* Numbers in the margin indicate pagination of original foreign text.

engines. About 14% of the coal mined was used for energy production, recalculated for stone coal. In the entire world, about 60% of the energy is provided by steam generating plants.

The search for new energy sources is based on the fact that our fuel reserves will be depleted in a hundred years or after a few hundred years, depending on the profitability of mining the coal and on the increase in the electrical power demand. Of course the profitable water resources must be expanded, because their source of energy is continuously recycled. However, the possibilities for satisfying our energy requirements in this way are limited and they are often exaggerated.

The studies on the exploitation of wind energy have led to solutions which can be built by present technology [4]. Generating plants with individual power levels of about 14,000 kW have been suggested, a level which is supposed to be an optimum one. Since the wind flow becomes more continuous as the altitude is increased, the wind wheel is supported about 250 m above the ground in a tower structure. It is either directly coupled with a slow generator or is coupled with several fast generators using a gear system. The dimensions of such a generating station with a diameter of 130 m for 10 rpm demonstrate the low energy flux density of the medium mentioned above.

There are numerous difficult problems associated with operating in parallel with an electrical network [5]. The power given off by the wind wheel is proportional to the third power of the wind velocity. According to Löbl, it increases according to the 3.5 power. When the wind velocity is changed by a ratio of 1:2 (normal phenomenon even for a "continuous wind"), the power ratios change at a ratio of 1:8. The device can be directly coupled to the net at a constant rotation rate by using directly connected synchronous generators. The coupling can also be done

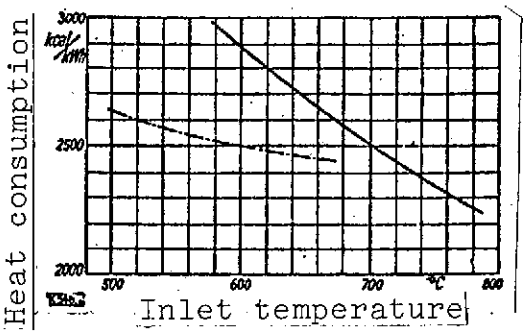

Figure 1. Heat Consumption in kcal/kWh as a function of inlet temperature

— · — 50 MW hot steam (140 gauge pressure).
——— 30 MW combustion turbine

TABLE 1. COMPARISON OF WIND GENERATING STATION AND STEAM GENERATING STATION

		Wind Force		Vapor Force
Installation costs*	RM/kW	1,000	200	250
Investment capital	10^6/RM	25	25	25
Power	kW	25,000	125,000	100,000
Full load use	h/years	2,000	2,000	6,000
Production	10^6 kWh/y	50	250	600
Heat consumption (WV)	kcal/kWh	-	-	3,000
Coal consumption (KV) (H_u = 6000)	kg/kWh	-	-	0.5
Coal price	RM/t	-	-	10
Heat cost	RM/10^6 kcal	-	-	1.67
Coal costs	Pf/kWh	-	-	0.5
Capital costs	%	10	10	12
Capital costs	RM/y	2,500,000	2,500,000	3,000,000
Capital costs	Pf/kWh	5.0	1.0	0.5
Total current production costs	Pf/kWh	5.0	1.0	1.0
WV of the replaced plant	kcal/kWh	5,000	5,000	5,000
KV of the replaced plant	kg/kWh	0.83	0.83	0.83
Coal savings	kg/kWh	0.83	0.83	0.83
Coal savings	t/y	41,500	208,000	198,000

* RM = 100 Pf = Reichs mark, prewar German currency.

using grid-controlled current rectifiers and alternating rectifiers at a rotation rate which corresponds to the wind velocity. As long as the wind power makes up only a small part of the overall network power, the "unsmoothed" raw energy of the wind force can be accepted by the network without any disturbances, if a power unit corresponding to the wind power is switched in the net. However, once large wind power levels are connected with the network, storage becomes necessary. The efficiency in delivering useful energy with storage devices is about 50% (large scale water reservoirs).

These remarks will only indicate a few problems associated with the large scale energy production using wind power. We do not say that this is a complete list.

In the final analysis, we want to save coal by installing wind electrical generating plants. We must then ask ourselves whether all the technical possibilities of producing energy from steam have been realized and exploited? This is not the case at all! This also results in a large coal savings with considerably less effort.

In 1943 in Germany we produced 1 kWh using 4500 kcal on the average, which corresponds to a thermal efficiency of 19%. During the war, this was increased to 5000 kcal/kWh and is certainly not lower today, even though the oldest and most uneconomical units are being employed. Using a high pressure generating station at 125 atmospheres gauge pressure and 500° C, it is possible to generate 1 kWh with a heat expenditure of 3000 kcal using the condensation method, which corresponds to a thermal efficiency of 28.7%. If all older generating stations were replaced by such high pressure generating stations, then this would result in a fuel savings of 40%. For the same amount of coal, this would result in a power increase of this amount.

The high pressure installations have been built and tested many times. This did not exhaust the technical possibilities of a steam driven process. I believe that there is a small technical risk associated with producing alloy components for building a 600° C steam generating plant than in building the suggested large scale wind generating station. With such an installation, it is possible to have a thermal efficiency of 35% (heat consumption: 2460 kcal/kWh.) If we also include the combustion generators in our discussion, we may evaluate the future development possibilities of heat generating plants according to Figure 1. The heat consumption is plotted in units of kcal/kWh as a function of the inlet temperature of the working medium. In the case of the steam generating plant, we assume a 1-stage intermediate overheating through the initial value. In the case of the gas generating plant, we assume two-stage combustion.

Energy production from nuclear reactions will not liberate us from the heating process. According to our knowledge, the radiation energy will have to be transformed into an electrical or mechanical energy by first generating heat energy. The costs (energy costs) for producing radioactive energy carriers represent the most important economic criterion for atomic reactors.

The statements mentioned above regarding heat generating plants all refer to pure energy production. There are even additional possibilities of saving fuel by combining energy production and heat production. In some cases, especially in the chemical industry, these have been completely exploited. / 528
In the future, there is the possibility of providing heat to both industry and homes (central city heating). Even though the installation costs including the distribution network will be considerably higher than for condensation generating plants, one kWh is produced at a heat expenditure of 1150 to 1200 kcal/kWh with counterpressure operation.

In this discussion we do not wish to compare the large scale wind generating plant with the thermal power plant of the future. Instead we only wish to compare it with the accepted and modern high pressure steam generating plants which operate at 125 atmospheres gauge pressure and 500° C. Table 1 is a simple calculation for the case where an older steam generating plant with a heat consumption of 5000 kcal/kWh is replaced either by a wind generating station or a modern steam generating station with a heat consumption of 3000 kcal/kWh. A certain amount of installation capital is assumed. The specific installation costs (RM/kW) for the wind generating station are about 4 times as high as for the steam generating station and the iron consumption is about the same for both. The assumed full load operational time of 2000 h/years does not have the same meaning for the wind generating station as for the thermal generating station. It is simply given by the quotient of the yearly power (kWh) and the installed power (kW). It is not actually possible to operate at full load for 2000 h/years. This is an assumed operational time during which energy is supplied, in contrast to the operational time of a thermal generating station which can always be operated under full load conditions, depending on the demands. The capital costs are 2% lower for the wind generating station than for the steam generating station, even though it is hardly possible to prove that this advantage does, indeed, exist. This calculation shows that the electricity production costs are five times as high for the wind generating plant than for the steam generating plant. The savings in coal amounts to only 1/5. The same current production costs and about the same savings in coal would be obtained if the installation costs for the wind generating station were lower than for the steam generating station. The assumed numerical values are not a requirement but should only be used for comparing the orders of magnitude. In addition, a storage facility is required for the wind generating station, which increases the current production costs to 10 to 20 Pf/kWh [5].

This simple discussion shows that as long as the thermal generating stations have not been improved as much as is technically feasible, there is no economic basis for building wind generating plants. The improvements to the thermal generating plants can be made with a fraction of the effort and costs of the wind generating plants.

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16. Abstract

Large wind power plants and their use to alleviate coal shortage in Germany; in author's opinion, there is no economic necessity for development of large scale wind power plants, before possible improvements in steam power plants, such as combined heating and power plants, high pressure plants, etc. have been exhausted; table gives comparison of costs and efficiency of wind and steam power plants.

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